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Efficacy of biological, organic and inorganic substrates of nutrients on yield attributing characters, sensory evaluation and economics of strawberry cv. Chandler under Lucknow conditions

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ABSTRACT

A field experiment was conducted for two years to study the performance of strawberry cv. Chandler as affected by the biological, organic and inorganic nutrient substrates under sub-tropical conditions. Integrated application of strawberry runners with bio-fertilizers, farmyard manure and NPK significantly influenced the yield and yield attributing characters, sensory attributes and benefit: cost ratio of strawberry grown under saline soils of sub-tropical conditions of Uttar Pradesh. Treatment T_8 [*Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%)] was most effective for commercial cultivation with higher yield (287.0 g/plant), better fruit quality, overall acceptability by the consumers and remunerative (B:C, 4.78:1.00) to the farmers compared to control (141.57 g/plant).

Key words: , *Azotobacter, Azospirillum*, integrated, Strawberry organoleptic test, yield.

INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch.) is a herbaceous perennial plant, which can be successfully cultivated from subtropical to temperate climate, *i.e*. upto 3,000 m above mean sea level with assured irrigation facility. It belongs the family Rosaceae and most of the cultivated varieties are octaploid (2n = 56). The ripe berry is red coloured, soft, highly perishable, has a sweet aroma (Sharma and Sharma, 8). Strawberry plant is a surface feeder, therefore, moisture, drainage, nutrients and microbial status of the upper layer of the soil have great impact on growth, development, fruit yield, quality and production of runners and thus, it needs effective nutrient management (Yadav *et al*., 15). Strawberry requires a number of mineral nutrients for proper growth and development (Darrow, 2). Nutrient management plays a key role in sustaining the productivity of the soil. The application of soil nutrients through chemical fertilizers is necessary to get optimum yield. However, deterioration in the soil health associated with the global crisis of energy, escalation in the prices of chemical fertilizers and environmental hazards lead to emphasize on the supplementation or substitution of chemical fertilizers with low priced nutrient sources such as biological and organic substrates.

The beneficial effects of integrated nutrient management in strawberry have been reported by some workers but in subtropical areas, especially those where the soil conditions are not suitable for its cultivation, *viz*., sodic soils *etc*., the integrated nutrient management practices still needs to be standardized especially with respect to the use of bio-fertilizers.

MATERIALS AND METHODS

A field experiment was conducted at Horticultural Research Farm of Department of Applied Plant Science (Horticulture), BBAU, Lucknow. Runners of strawberry cv. Chandler were procured from Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, (Solan), Himachal Pradesh, while biofertilizers (*Azotobacter* and *Azospirillum*) from Pant Bio Lab, Pantnagar (Uttarakhand). The strawberry runners of uniform size were planted on ridges at a spacing of 15 cm x 30 cm by accommodating 30 plants / plot in first week of November during both the years of experimentation. Strawberry crop were fertilized with recommended (100%) and half of the recommended doses (50%) of integrated sources of nutrients, *viz*., NPK @ 90, 75 and 60 kg/ha, FYM @ 50 tonnes/ha and biofertilizers (*Azotobacter* and *Azospirillum*) @ 50 ml in 20 litres of water according to the treatment combination. The design of the experiment was randomized block design with three replications and 12 treatment combinations as follows: T_1 = control (recommended dose of NPK), T_2 = *Azotobacter* (100%), T_3 = *Azospirillum* (100%), T_4 = FYM, T_5 = *Azotobacter* (50%) + *Azospirillum* (50%), T_6 = *Azotobacter* (100%) + NPK (50%), T_7 = *Azospirillum* (100%) + NPK (50%), T_8 = *Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%), T_9 = *Azotobacter* (100%) + FYM, T_{10} = *Azospirillum* (100%) + FYM, T_{11} = *Azotobacter* (50%) + *Azospirillum* (50%) + FYM, T_{12} = *Azotobacter* (50%) + *Azospirillum* (50%)

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+ NPK (50%) + FYM. The required quantity of farm yard manure (FYM) as per treatment combination was applied at the time of land preparation. Urea was applied in two split doses before planting and flowering stages, while the full dose of phosphorus and potash was given before planting. *Azotobacter*, *Azospirillum* and *Azotobacter* + *Azospirillum* solutions were made by dissolving 50 ml of suspension in 20 l of water. The roots of the strawberry runners were thoroughly dipped in the solution for about 30 min. and then planting as done. Yellow polythene of 200 gauge was used as mulch material (Singh and Dwivedi, 11). Appropriate management practices were adopted to raise the crop.

Nine plants were randomly selected for recording the reproductive parameters, *viz*., number of flowers/ plant and number of fruits/ plant starting from 60 days after transplanting (DAT) at an interval of 15 days and the average was worked out. At the time of berry picking, 5 fruits/ plant (20 plants/ plot) were collected for measurement of fruit length, diameter and weight. Sensory evaluation was carried out after the harvesting of fruits by using a panel of 15 judges. Nine point Hedonic scale was used for organoleptic evaluation of strawberry fruit. The fruits of different treatments were compared for different sensory attributes, *viz.*, appearance, size, shape, colour, texture, odour, taste, sweetness, acidity, firmness, juiciness and overall preference and were scored on a scale of 1-9, *i.e.*, score 1 for very bad, 3 for bad, 5 for medium, 7 for good and 9 for excellent. The data were analysed statistically.

RESULTS AND DISCUSSION

An inquisition of the pooled data in Table 1 showed that the application of different integrated sources of nutrients had significant effect over control on yield attributing characters of strawberry plants. The maximum number of flowers per plant, *i.e.*, 0.96, 3.05, 4.17, 6.35, 8.19 and 7.92 and fruits per plants, *i.e.* 0.56, 2.88, 4.11, 6.25, 8.15 and 6.89 at 60, 75, 90, 105, 120 and 135 days after transplanting were recorded in treatment T_8 (half of the recommended dose of biofertilizers *Azotobacter* + *Azospirillum* and inorganic fertilizer) followed by T_{11} (half of the recommended dose of biofertilizers and farmyard manure). While the minimum was recorded in treatment T_4 where the plants were treated with recommended dose of farmyard manure closely followed by treatment T_1 (control). It is also evident from the pooled data mentioned in the above table that there is gradual increase in the number of flowers and fruits upto 120 days after transplanting and then a decline was observed. It is also evident from the data that dual inoculation of biofertilizers significantly produced more number of fruits per plant, *i.e.*, in treatments T_{12}, T_{11}, T_8 and T_5 than their single inoculation, *i.e.* treatments T_2 and T_3.

The maximum fruit length (3.83 cm), fruit diameter (2.82 cm), fruit weight (9.95 g), fruit volume (8.80 ml)

Table 1. Influence of biological, organic and inorganic nutrient substrates on number of flowers and number of fruits per plant of strawberry cv. Chandler (pooled data of two years).

Treatment	No. of flowers/ plant						No. of fruits/ plant					
DAT	60	75	90	105	120	135	60	75	90	105	120	135
T_1	0.36	2.18	3.27	4.48	5.50	4.65	0.17	1.94	3.17	4.39	5.44	4.65
T_2	0.43	2.34	3.59	4.64	6.37	5.14	0.23	2.07	3.40	4.59	6.33	5.12
T_3	0.41	2.25	3.49	4.61	6.12	4.79	0.21	2.03	3.35	4.52	6.05	4.80
T_4	0.32	2.12	3.13	4.32	5.42	4.47	0.14	1.92	3.04	4.24	5.34	4.45
T_5	0.50	2.38	3.68	4.73	6.40	5.20	0.26	2.19	3.47	4.63	6.34	5.13
T_6	0.76	2.56	3.91	5.07	6.84	5.84	0.43	2.46	3.76	5.01	6.79	5.77
T_7	0.70	2.52	3.80	4.98	6.79	5.65	0.41	2.30	3.67	5.00	6.76	5.75
T_8	0.96	3.05	4.17	6.35	8.19	7.92	0.56	2.88	4.11	6.25	8.15	6.89
T_9	0.60	2.46	3.80	4.88	6.65	5.56	0.31	2.23	3.59	4.93	6.64	5.52
T_{10}	0.56	2.42	3.74	4.84	6.54	5.43	0.29	2.19	3.49	4.92	6.56	5.49
T_{11}	0.90	2.84	4.04	6.32	8.10	6.93	0.48	2.70	4.00	6.19	8.10	6.86
T_{12}	0.86	2.74	4.00	6.08	8.00	6.38	0.45	2.62	3.84	5.94	7.95	6.31
CD at 5%	0.058	0.168	0.094	0.302	0.279	0.683	0.039	0.272	0.335	0.334	0.489	0.411

Where, DAT = Days after transplanting; T_1 = control; T_2 = *Azotobacter* (100%); T_3 = *Azospirillum* (100%); T_4 = FYM only; T_5 = *Azotobacter* (50%) + *Azospirillum* (50%); T_6 = *Azotobacter* (100%) + NPK (50%); T_7 = *Azospirillum* (100%) + NPK (50%); T_8 = *Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%); T_9 = *Azotobacter* (100%) + FYM; T_{10} = *Azospirillum* (100%) + FYM; T_{11} = *Azotobacter* (50%) + *Azospirillum* (50%) + FYM and T_{12} = *Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%) + FYM.

and yield (287.04 g/plant) were recorded (Table 2) with half of the dual inoculation of biofertilizers and half of the recommended doses of fertilizers (T_8) followed by half of the dual inoculation of biofertilizers along with recommended dose of organic manure (T_{11}). These findings are in agreement with that of Anon (1), who recorded highest yielded of 20.2 and 20.6 t/ ha, with bioinoculants (*Azotobacter* + *Azospirillum*) when applied in tomato crop with 75 and 100% nitrogen and phosphorus doses, respectively. This increased reproductive parameters and yield may be due to the cumulative effect of biofertilizers and inorganic fertilizers and the fact that nitrogen fixers not only increased the availability of nitrogen to the plant roots but also increased their translocation from root to flower through foliage (Singh and Singh, 9).

The total yield and yield attributing characters (Table 2), *i.e.* total number of flowers, total number of fruits, fruit length, fruit width, fruit weight and fruit volume in treatment T_{12} containing *Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%) + recommended dose of farmyard manure was slightly lower than that observed in treatment T_8 [*Azotobacter* (50%) + *Azospirillum* (50%) and inorganic fertilizers (50%)] and T_{11} [*Azotobacter* (50%) + *Azospirillum* (50%) + farmyard manure]. This result got the support from the findings of Mukkun *et al.* (5) who found that fruit formation reduced significantly as nitrogen rate was increased in strawberry cv. Chandler, Gupta and Tripathi (3) also recorded higher number of flowers per plant, higher number of fruits per plant and total yield (324.38 g/plant) with *Azotobacter* (6 kg/ha) + vermicompost (30 t/ha) over *Azotobacter* (7 kg/ ha) + vermicompost (30 t/ha) with 236.07 g/ plant. Umar *et al.* (14) also observed highest yield of strawberries (372.89 q/ha) in plants treated with biofertilizers + NPK (100%) as compared to biofertilizers + FYM + NPK applied plants with yield of 309.51 q/ ha. Therefore, the result of present study duly corroborated by earlier studies that increased level of nitrogen through any source does not always increase the yield.

Combined inoculation of biofertilizers (*Azotobacter* and *Azospirillum*) either with inorganic fertilizers (T_8) or with farmyard manure (T_{11}) recorded more berry yield, *i.e.* 287.04 g/plant and 275.14 g/plant, respectively, which was significantly higher over sole inoculation of biofertilizers, *i.e.* with *Azotobacter* treated plants and T_2 (173.69 g/plant) or *Azospirillum* treated plants, *i.e.* T_3 (155.30 g/plant). Singh *et al.* (11) also recorded high yield (259.37 g/plant) in strawberry cv. Chandler under organic production system. Talukder and Jana (13) also stated that in the absence of inorganic nitrogen comparatively less green fruit yield was recorded from the plots treated with sole or dual inoculation of *Azotobacter* and *Azospirillum.*

The increased berry attributes and yield by the combined inoculation of biofertilizers might be due to the enhanced fixation of nitrogen in dual inoculation by

Table 2. Influence of biological, organic and inorganic nutrient substrates on fruit physical parameters, yield and B:C ratio of strawberry cv. Chandler (pooled data of 2 years).

Treatment	Fruit length (cm)	Fruit width (cm)	Fruit wt. (g)	Fruit vol. (ml)	Yield (g/plant)	Benefit : cost ratio
T_1	3.20	2.42	7.12	6.62	141.57	1.84
T_2	3.39	2.52	8.00	7.59	173.69	2.50
T_3	3.28	2.45	7.50	7.31	155.30	2.13
T_4	3.11	2.37	6.23	6.11	122.53	1.44
T_5	3.45	2.60	8.15	7.64	179.76	2.62
T_6	3.66	2.69	8.62	8.00	206.88	3.16
T_7	3.62	2.66	8.57	7.94	203.03	3.09
T_8	3.83	2.82	9.95	8.80	287.04	4.78
T_9	3.60	2.64	8.40	7.83	194.05	2.87
T_{10}	3.58	2.60	8.35	7.73	191.47	2.82
T_{11}	3.78	2.77	9.71	8.70	275.14	4.50
T_{12}	3.72	2.72	9.09	8.11	247.70	3.94
CD at 5%	0.210	0.135	0.713	0.722	13.663	

Where, DAT = Days after transplanting; T_1 = Control; T_2 = *Azotobacter* (100%); T_3 = *Azospirillum* (100%); T_4 = FYM only; T_5 = *Azotobacter* (50%) + *Azospirillum* (50%); T_6 = *Azotobacter* (100%) + NPK (50%); T_7 = *Azospirillum* (100%) + NPK (50%); T_8 = *Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%); T_9 = *Azotobacter* (100%) + FYM; T_{10} = *Azospirillum* (100%) + FYM; T_{11} = *Azotobacter* (50%) + *Azospirillum* (50%) + FYM and T_{12} = *Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%) + FYM.

nitrogen fixing bacteria that played an important role in assimilation of numerous amino acids, which might have helped in increasing the photosynthesis efficiency (Rana and Chandel, 7). Synergism among *Azotobacter* and *Azospirillum* might have resulted in better berry yield with their combined inoculation as against single inoculation. These findings are in line with Talukder and Jana (13) on chilli who stated that dual inoculation of biological nitrogen fixers always recorded better performance when compared with their single inoculation (Anon, 1; Singh *et al*., 12). Single inoculation of strawberry runners with *Azotobacter* and *Azospirillum* significantly increased the berry yield, being 173.69 and 155.30 g/plant, respectively, over control (141.57 g/plant). This result is in conformity with the findings of Pandit *et al.* (6) who recorded higher yield (316.40 g/plant) with *Azotobacter* treated plants, over *Azospirillum* treated plants (281.44 g/plant) and control (237.57 g/plant). The results for the sensory attributes ratings across the treatments due to the impact of integrated nutrient management are presented in Table 3. Hedonic ratings of strawberry under different nutritional treatments shows that Treatment T_{11} exhibited the highest rating for most of the sensory attributes, *viz*., appearance (7.00), shape (7.40), colour (7.90), texture (7.90), aroma (7.40), taste (7.55), sweetness (7.45), acidity (8.15), firmness (8.30) and juiciness (8.00) among different nutritional treatments being at par with the treatment T_8 with the ratings (6.90) appearance, (7.20) shape, (7.75) colour, (7.80) texture, (7.30) aroma, (7.48) taste, (7.45) sweetness, (8.10) acidity, (8.15) firmness, and juiciness (7.90), which were highly significant over control having minimum values. Highest hedonic rating for the size of strawberry fruits (6.80) was in treatment - T_8, non-significant with treatment T_{11} (6.75), however, it was highly significant over control (5.15), while the minimum rating for size was obtained in treatment T_4 (5.00). Thus, fruits of treatment T_{11} showed overall acceptability by the consumers, which was statistically at par with the fruits of T_8. Similar results with press mud, inorganic and bio-fertilizers on strawberry were noted by Kumar *et al.* (4).

In the present investigation, economic aanalysis of various treatments reveals that application of half of the recommended dose of *Azotobacter* + *Azospirillum* + NPK (T_8) gave the maximum benefit : cost ratio (4.78) followed by T_{11} (4.50) over control (1.84) and other treatments. This increase in monetary return may be attributed to higher yield of berries and low cost of cultivation. Such results also tally with the findings of Yadav *et al.* (15) in strawberry who recorded highest B:C ratio (4.97) with the application of *Azotobacter* + 50% N through FYM + 50% N through inorganic fertilizers and Talukder and Jana (13) who recorded increased monetary benefits with B:C ratio of 1.55 and 1.53 in chilli plants treated with 100 and 75% of recommended dose of inorganic nitrogen, respectively with dual inoculation of biological nitrogen fixers like *Azotobacter* and *Azospirillum* and application of organic manure. The results obtained led to the inference that treatment T_8 [*Azotobacter* (50%) +

Table 3. Influence of biological, organic and inorganic substrates of nutrients on sensory evaluation of strawberry fruits cv. Chandler (pooled data of two years).

Sensory attribute	Treatment												$CD_{0.05}$
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	
Appearance	5.50	5.90	5.70	5.60	6.10	6.45	6.30	6.90	6.70	6.55	7.00	6.80	0.074
Size	5.15	5.50	5.20	5.00	5.75	6.55	6.42	6.80	6.15	5.90	6.75	6.70	0.058
Shape	4.80	5.32	5.25	5.00	5.90	6.57	6.10	7.20	6.95	6.70	7.40	7.14	0.085
Colour	6.20	6.75	6.50	6.40	6.85	7.10	6.90	7.75	7.50	7.35	7.90	7.60	0.131
Texture	6.25	6.70	6.57	6.35	7.05	7.50	7.28	7.80	7.60	7.60	7.90	7.65	0.063
Aroma	5.40	6.00	5.71	5.50	6.28	6.75	6.42	7.30	7.10	6.90	7.40	7.25	0.142
Taste	6.00	6.45	6.30	6.15	6.65	7.00	6.90	7.48	7.28	7.15	7.55	7.40	0.124
Sweetness	6.00	6.42	6.28	6.20	6.48	6.80	6.65	7.45	7.15	6.95	7.45	7.30	0.071
Acidity	6.20	6.80	6.50	6.40	7.00	7.30	7.10	8.10	7.85	7.50	8.15	7.90	0.142
Firmness	6.50	7.15	7.00	6.80	7.30	7.60	7.50	8.15	7.90	7.85	8.30	8.00	0.081
Juiciness	5.85	6.80	6.57	6.15	7.15	7.50	7.30	7.90	7.70	7.60	8.00	7.80	0.130

Where, DAT = Days after transplanting; T_1 = Control; T_2 = *Azotobacter* (100%); T_3 = *Azospirillum* (100%); T_4 = FYM only; T_5 = *Azotobacter* (50%) + *Azospirillum* (50%); T_6 = *Azotobacter* (100%) + NPK (50%); T_7 = *Azospirillum* (100%) + NPK (50%); T_8 = *Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%); T_9 = *Azotobacter* (100%) + FYM; T_{10} = *Azospirillum* (100%) + FYM; T_{11} = *Azotobacter* (50%) + *Azospirillum* (50%) + FYM and T_{12} = *Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%) + FYM; Fruits were scored on the sensory attributes on a scale of 1- 9.

Azospirillum (50%) + NPK (50%)] performed best in case of reproductive growth parameters (flowering, fruiting and yield), while T_{11} [*Azotobacter* (50%) + *Azospirillum* (50%) + FYM] performed best for fruit quality parameters of strawberry. However, if we look the overall performance of the strawberry crop, the results obtained with treatment T_8 was statistically at par with those obtained in treatment T_{11} for biochemical parameters or quality of fruits.

The acceptance of any agricultural recommendation will mainly depend upon its benefit: cost ratio. In the present investigation, the maximum benefit: cost ratio was obtained in treatment T_8. Thus, based on the results, it is concluded that integration of inorganic fertilizers with biofertilizers may not only achieve highest strawberry yield and net returns but also improved the quality of fruits and fertility of soils. The treatment T_8 [*Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%)] may be of interest for commercial growing of strawberries in Uttar Pradesh with higher yield, better quality fruits, overall acceptability by the consumers and higher benefit to the farmers.

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